

## The Role of Bronchoscopy as a Diagnostic and Therapeutic Modality in Critically Ill Patients with Respiratory Failure and Pneumonia in the Intensive Care Unit: A Descriptive Observational Study

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### ABSTRACT

**Introduction:** Respiratory failure remains a major cause of intensive care unit (ICU) admission and is associated with substantial morbidity and mortality worldwide. Pneumonia frequently results in respiratory failure requiring invasive mechanical ventilation. Bronchoscopy enables direct airway visualization and bronchoalveolar lavage (BAL), providing important diagnostic and therapeutic benefits in critically ill patients. This study evaluated the role of bronchoscopy in ICU patients with pneumonia-associated respiratory failure.

**Methods:** This descriptive observational study was conducted in the adult ICU of RSUP H. Adam Malik Medan, Indonesia. Adult patients with pneumonia-associated respiratory failure requiring invasive mechanical ventilation who underwent bronchoscopy during ICU treatment in December 2025 were included. Data were obtained from medical records, bronchoscopy reports, laboratory investigations, and radiological examinations. Outcomes included chest radiographic findings, leukocyte count, neutrophil-to-lymphocyte ratio (NLR), and BAL culture results.

**Results:** Eighteen patients were included. Radiological improvement was observed in 13 patients (72%), whereas deterioration was observed in five (28 %) patients. Improvement in leukocyte count occurred in 16 (89%) patients, and improvement in NLR was identified in 15 (83%) patients. BAL cultures predominantly revealed *Acinetobacter baumannii*, followed by *Klebsiella pneumoniae* and *Pseudomonas aeruginosa*.

**Conclusion:** Bronchoscopy provides important diagnostic and therapeutic benefits in ICU patients with pneumonia-associated respiratory failure by facilitating airway clearance, improving inflammatory parameters, and supporting targeted antimicrobial therapies.

Bronchoscopy, Intensive Care Unit, Pneumonia, Respiratory Failure, Bronchoalveolar Lavage

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## INTRODUCTION

Respiratory failure remains one of the leading causes of intensive care unit (ICU) admission and is associated with substantial morbidity and mortality [1]. Pneumonia is a major contributor to respiratory failure in critically ill patients and frequently necessitates invasive mechanical ventilation. Community-acquired pneumonia

(CAP), hospital-acquired pneumonia (HAP), and ventilator-associated pneumonia (VAP) are among the most prevalent pulmonary infections encountered in the ICU [2]. Despite advances in antimicrobial therapy and critical care management, pneumonia-associated respiratory failure continues to impose a significant clinical burden because of prolonged hospitalization, increased healthcare costs, and poor patient outcomes [3]. The diagnosis of pneumonia in critically ill patients remains challenging because the clinical manifestations and radiological findings are often nonspecific and may overlap with other pulmonary conditions, including pulmonary edema, atelectasis, and acute respiratory distress syndrome (ARDS) [4]. In mechanically ventilated patients, altered pulmonary physiology and the presence of endotracheal tubes further complicate the microbiological assessment. Conventional microbiological investigations using non-invasive respiratory specimens frequently demonstrate limited sensitivity and specificity, potentially delaying appropriate antimicrobial therapy and contributing to the emergence of antimicrobial resistance [5].

Flexible bronchoscopy has become an essential modality in modern critical care practice because it allows direct visualization of the tracheobronchial tree and facilitates the collection of lower respiratory tract specimens through bronchoalveolar lavage (BAL) [6]. BAL improves microbiological diagnostic accuracy by enabling the identification of causative pathogens in severe pneumonia, particularly in patients with VAP and refractory pulmonary infections [7]. Accurate pathogen identification is crucial for optimizing antimicrobial stewardship and guiding targeted antimicrobial therapy in critically ill patients [8]. In addition to its diagnostic utility, bronchoscopy also provides important therapeutic benefits. The procedure enables the removal of retained secretions, mucus plugs, blood clots, and airway debris that may impair ventilation and gas exchange [9]. Airway clearance through bronchoscopy may improve pulmonary mechanics, enhance oxygenation, and facilitate lung expansion in mechanically ventilated patients [10]. Consequently, bronchoscopy is increasingly utilized as both a diagnostic and therapeutic intervention in ICU management.

## METHOD

This descriptive observational study was conducted in the adult intensive care unit (ICU) of RSUP H. Adam Malik Medan, a tertiary referral hospital in Medan, Indonesia. The study was performed during December 2025 to evaluate the diagnostic and therapeutic role of bronchoscopy in critically ill patients with pneumonia-associated respiratory failure. Adult patients diagnosed with respiratory failure secondary to pneumonia who required invasive mechanical ventilation and underwent bronchoscopy during ICU treatment were included in this study. Pneumonia cases comprised community-acquired pneumonia (CAP), hospital-acquired pneumonia (HAP), and ventilator-associated pneumonia (VAP).

Patients were included if they were aged  $\geq 18$  years, had a confirmed diagnosis of pneumonia-associated respiratory failure, underwent bronchoscopy with bronchoalveolar lavage (BAL), and received invasive mechanical ventilation during ICU admission. Patients with incomplete medical records or those who underwent bronchoscopy for indications unrelated to pneumonia were excluded from the study. Clinical data were retrospectively collected from electronic medical records, bronchoscopy procedure reports, laboratory investigations, and radiological examinations. Demographic characteristics, clinical findings, bronchoscopy results, microbiological culture findings, and inflammatory laboratory parameters were systematically reviewed and analyzed. Flexible bronchoscopy was performed by anesthetists experienced in critical care bronchoscopy according to standard ICU protocols. Bronchoalveolar lavage specimens were obtained from the affected pulmonary segments under aseptic conditions and subsequently sent for microbiological culture and pathogen identification. The primary outcomes evaluated in this study included changes in chest radiographic findings, leukocyte count, neutrophil-to-lymphocyte ratio (NLR), and BAL culture results following bronchoscopy. Radiological improvement was assessed through comparative chest X-ray evaluation before and after the procedure, whereas laboratory improvement was determined based on changes in leukocyte count and NLR values during ICU treatment.

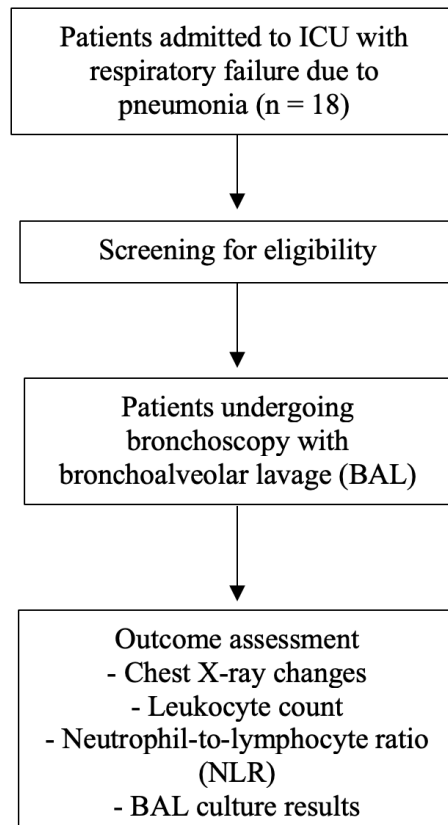


Figure 1. Flow Diagram of Patient Selection

**RESULTS**

We included 18 patients with pneumonia-associated respiratory failure who underwent bronchoscopy during ICU treatment. The mean patient age was  $62.6 \pm 13.8$  years, with a median age of 59 years (range, 39–86 years). Male patients predominated, accounting for 61.1% of the study population.

Table 1. Demographic Characteristics of Study Participants (n = 18)

Characteristic	Value
Age, mean $\pm$ SD (years)	62.6 $\pm$ 13.8
Age, median (min–max) (years)	59 (39–86)
Male, n (%)	11 (61.1)
Female, n (%)	7 (38.9)

Clinical and radiological improvements were observed in most patients following bronchoscopy. Improvements in chest radiographic findings were identified in 13 patients (72%), whereas radiological deterioration occurred in five patients (28%). Improvement in leukocyte count was observed in 16 patients (89%), whereas worsening laboratory findings were observed in only two patients (11 %). Similarly, improvement in neutrophil-to-lymphocyte ratio (NLR) was identified in 15 patients (83%), whereas deterioration occurred in three patients (17%).

Table 2. Changes in Clinical Parameters After Bronchoscopy (n = 18)

Parameter	Improvement, n (%)	Deterioration, n (%)
Chest X-ray findings	13 (72.2)	5 (27.8)
Leukocyte count	16 (88.9)	2 (11.1)
Neutrophil-to-lymphocyte ratio	15 (83.3)	3 (16.7)

Bronchoalveolar lavage cultures revealed the presence of several pathogenic microorganisms. *Acinetobacter baumannii* was the most frequently isolated organism, identified in nine patients (50% of cases).

*Klebsiella pneumoniae* was detected in five patients (27.8%), followed by *Pseudomonas aeruginosa* in three (16.7%). Other microorganisms were identified less frequently than the above-mentioned species.

Table 3. Microorganisms Identified from BAL Cultures

Microorganism	Number of Patients, n	Percentage (%)
<i>Acinetobacter baumannii</i>	9	50.0
<i>Klebsiella pneumoniae</i>	5	27.8
<i>Pseudomonas aeruginosa</i>	3	16.7
Other microorganisms	1	5.6

## DISCUSSION

This study evaluated the role of bronchoscopy as a diagnostic and therapeutic modality in patients with ICU-acquired pneumonia and associated respiratory failure. The findings demonstrated that bronchoscopy was associated with radiological and inflammatory improvement in the majority of critically ill patients. These results support the growing role of bronchoscopy as an important adjunctive procedure in modern critical care practice [11]. Radiological improvement was observed in most patients after bronchoscopy, indicating enhanced pulmonary aeration and airway patency. This finding may be attributed to the therapeutic effect of bronchoscopy in removing retained secretions and mucus plugs that impair ventilation and gas exchange in mechanically ventilated patients [12]. Airway obstruction caused by thick secretions is a common complication in critically ill patients and may contribute to atelectasis, worsening oxygenation, and prolonged ventilation support [13]. Therefore, bronchoscopic airway clearance may provide clinically meaningful benefits by improving pulmonary mechanics and facilitating alveolar recruitment.

In addition to radiological improvement, inflammatory parameters showed favorable changes after bronchoscopy. Improvements in leukocyte count and neutrophil-to-lymphocyte ratio (NLR) were observed in most patients, suggesting attenuation of the systemic inflammatory response following airway clearance and optimization of antimicrobial therapy [14]. The NLR has been widely recognized as a useful inflammatory biomarker associated with infection severity, systemic inflammation, and clinical outcomes in critically ill patients with pneumonia [15]. Therefore, the reduction in the inflammatory burden after bronchoscopic intervention may reflect improved infection control and pulmonary stabilization. Microbiological analysis of BAL specimens identified *Acinetobacter baumannii* as the predominant pathogen. This finding is consistent with previous reports demonstrating the high prevalence of *Acinetobacter baumannii* in hospital-acquired pneumonia and ventilator-associated pneumonia in intensive care unit (ICU) settings [16]. The emergence of multidrug-resistant gram-negative organisms remains a major challenge in critical care medicine, particularly in mechanically ventilated patients receiving prolonged ICU treatment [17]. BAL culture obtained through bronchoscopy enables more accurate pathogen identification and supports targeted antimicrobial therapy based on microbial susceptibility patterns [18]. Consequently, bronchoscopy may contribute not only to diagnostic precision but also to antimicrobial stewardship efforts aimed at reducing inappropriate antibiotic exposure and limiting antimicrobial resistance [19].

The present study has several limitations. First, it was conducted at a single center with a relatively small sample size, which may limit the generalizability of the findings. Second, the observational design precludes definitive conclusions regarding causality between bronchoscopy and clinical improvement. Nevertheless, this study provides important preliminary evidence regarding the potential diagnostic and therapeutic benefits of bronchoscopy in ICU patients with pneumonia-associated respiratory failure. Overall, the findings of this study support the integration of bronchoscopy into comprehensive ICU management strategies, particularly in mechanically ventilated patients with severe pneumonia requiring airway clearance and microbiological evaluation.

## CONCLUSION

Bronchoscopy provides significant diagnostic and therapeutic value in ICU patients with pneumonia-associated respiratory failure by facilitating airway clearance, improving inflammatory parameters, and

enabling accurate microbiological identification through bronchoalveolar lavage cultures. These findings support bronchoscopy as an important adjunctive intervention in the comprehensive management of critically ill patients with severe pneumonia who require invasive ventilation.

#### **DECLARATIONS**

This study was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Ethics Committee of RSUP H. Adam Malik Medan. Owing to the retrospective nature of the study and the use of anonymized clinical data, the requirement for informed consent was waived by the Ethics Committee.

#### **CONSENT FOR PUBLICATION**

The authors agree to the publication of this article in the Journal of Society Medicine.

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